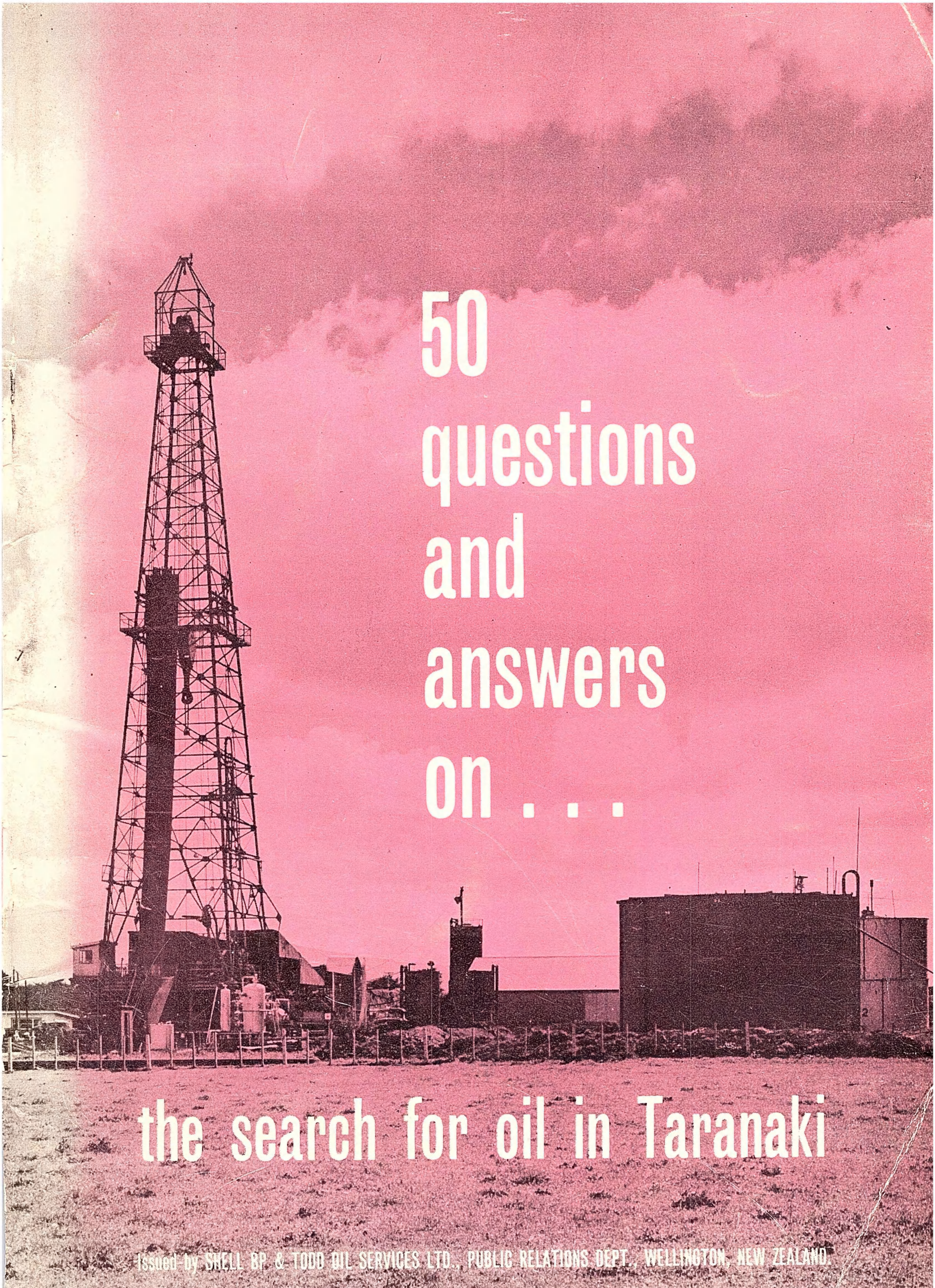

50 questions and answers on . . .

the search for oil in Taranaki

Issued by SHELL BP & TODD OIL SERVICES LTD., PUBLIC RELATIONS DEPT., WELLINGTON, NEW ZEALAND.

Shell BP & Todd Oil Services Limited, formerly Shell D'Arcy and Todd Oil Services Limited, is a private company registered in Wellington, and jointly owned by Shell Oil New Zealand Limited, BP (New Zealand) Limited and Todd Brothers Limited, which, although completely separate organisations, have joined together to share the risks of the oil search in several parts of New Zealand.

The policy of the company is governed by a Board of Directors, on which all three partners are represented. The Chairman of the Board is Mr. J. B. Price.

The registered office of the company is at Shell House, The Terrace, Wellington, and the Taranaki Office is located in the Bank of New Zealand Building, Devon Street, New Plymouth.

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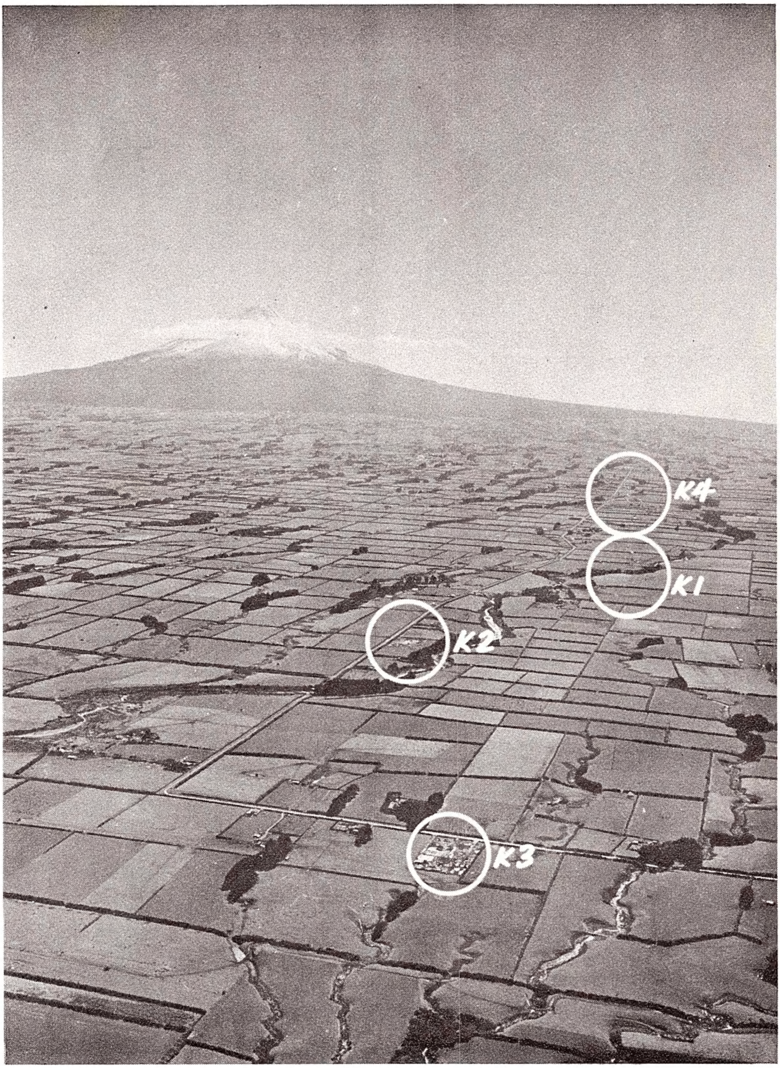


An aerial photograph of the Kapuni district, showing the location of the original "wildcat" well - Kapuni 1 - and the three subsequent appraisal wells.

FOREWORD

Since starting the present search for oil in Taranaki in 1955, we have received many hundreds of letters and enquiries asking for information about the work we are doing. There is everywhere a keen and growing interest in it and now that it looks as if our efforts are going to be successful, the interest is growing even greater.

Naturally we share the hopes of all the many New Zealanders who have been following our progress so keenly, and since natural gas and condensate now seem almost certain to play a very important part in the economic life of this country, we are anxious that the background to the new industry which is now springing into life should be known.

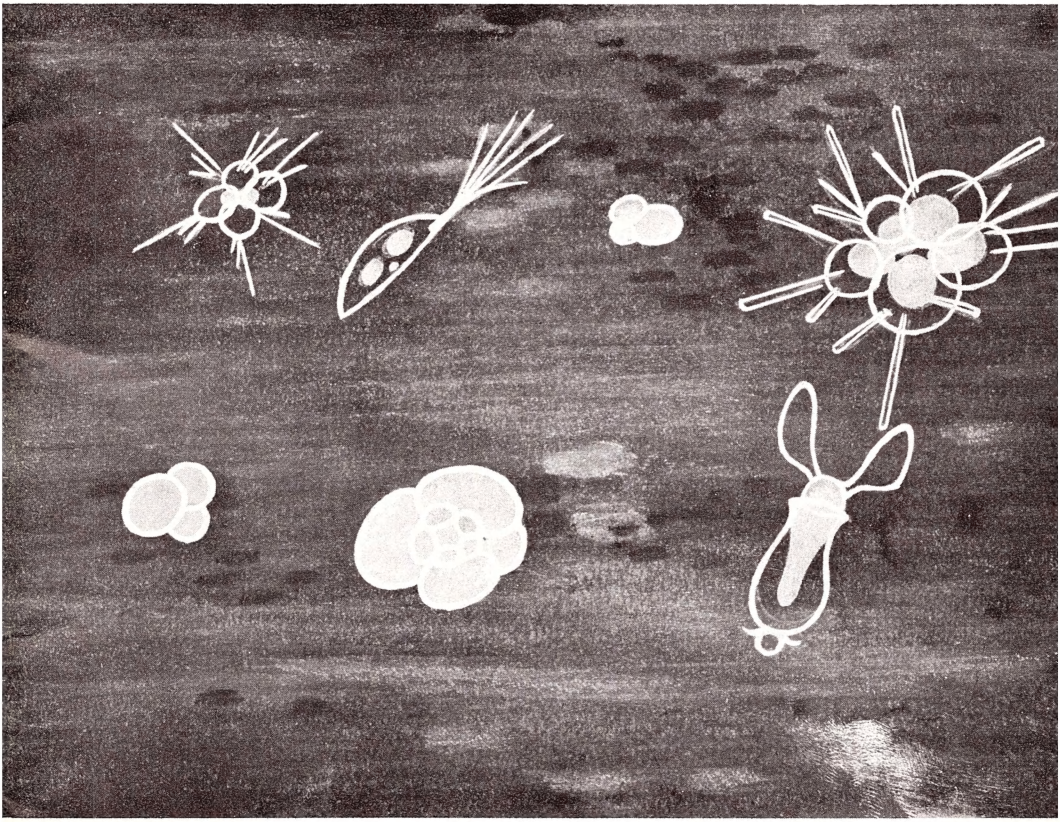
How is oil formed? What is condensate? Why does it take so long to find commercial production? This is the kind of question we have tried to answer in this booklet. We hope it will prove to be interesting and informative to many New Zealanders.

D. S. Watt,
General Manager.


NORTH TARANAKI BIGHT
Urenui
Waitara
MANGAHEWA - I
NEW PLYMOUTH
Oakura
Inglewood
INGLEWOOD-A
Okata
MT. EGMONT
Stratford
Rahotu
Eltham
Opunake
KAPUNI-4
KAPUNI-1
KAPUNI-2
KAPUNI-3
Pihama
Otakeho
Manaia
Hawera
SOUTH TARANAKI BIGHT
Patea
Waverley
EXPLORATION AND APPRAISAL WELLS
TARANAKI PENINSULA
SHELL B.P. AND TODD OIL SERVICES LTD
AUGUST 1962

SECTION I

THE ORIGIN OF OIL



SECTION I

Question 1 - How is Oil Formed?

The primary requirement is an environment of shallow warm seas (such as for example, the Gulf of Mexico or the Persian Gulf) in which the water is rich in animal or vegetable life, usually marine organisms, large or microscopic.

The second requirement is that the organisms, on dying, should sink to the bottom of the sea and be buried by mud from rivers, in the way that mud from the Mississippi buries millions of organisms daily as it settles on the floor of the Gulf of Mexico.

Conditions must be such on the sea bottom that no rapid decay of the dead organisms takes place; for instance, the oxygen content of the water must be low. Thick accumulations of sediment above the layers containing the organic matter increase the pressure and the temperature in these source beds. These conditions, assisted by bacteria, and possibly also by radio-activity, transform the soft parts of the organisms into oil and gas.

Question 2 - How long does Oil take to form?

Oil probably forms fairly soon after the dead organisms are buried on the sea floor, but the process has been going on for the past 500 million years.

Question 3 - Does the fact that oil is formed from dead marine life, mean that oil can only be found in land that was once under the sea?

Generally speaking, yes. Oil is always formed in rocks that were once under the sea, but in the course of time it may move or migrate to other porous rocks that have not been under the sea.

Question 4 - How does this migration take place?

So long as the adjoining formations are penetrable enough to allow the passage of fluids through the pores of the rocks (or through a system of cracks and fractures), most of the oil and gas together with some of the associated water is squeezed out of the source rock under the pressure of the layers which in the course of time are deposited above it. Thus the rock fluids start to migrate either upwards or sideways, or possibly downwards. It is difficult to say how far oil can migrate in this way but there is evidence that it has travelled over large distances, even dozens of miles.

Question 5 - In what circumstances does oil accumulate in recoverable quantities underneath the ground?

Oil accumulates in recoverable quantities when an area of oil-bearing porous rock becomes trapped by a

surrounding or overlying layer of impervious rock. Oil tends to move upwards and if there were nothing to stop it, it would gradually rise to the surface of the ground and come through as a seepage. There are numerous seepages in many parts of New Zealand.

When the earth's crust is broken up, folded or faulted however, impervious rock is sometimes thrown around an area of porous rock forming a trap, which effectively prevents the escape of oil and gas. It is traps of this kind that oil explorers look for.

There is little doubt that a large percentage of the oil formed during geological history has escaped to the surface as seepages and has evaporated or been burnt off in the millions of years before man appeared on earth and learnt to extract and use the small percentage which was left behind.

Question 6 - Does a trap always contain oil?

No. It is merely a geological structure which might contain oil. Only by drilling can we find out if it does. Usually it will only contain water, either fresh or salt.

Question 7 - Why do geologists consider Taranaki to be an area in which oil might be found?

More than fifty years of geological

oil exploration all over the world have made it possible to decide broadly whether, in the geological past, conditions may have been suitable for the origination and accumulation of oil. In general, these conditions are to be found in the down-warped segments of the earth's crust, where layers of sediments have accumulated to great thicknesses. In each of these areas the sediments are usually thickest in the middle and thin out towards the edges. They are called sedimentary basins and are considered as potential "oil basins", worth investigating for the presence of oil until its absence has definitely been proved. The Taranaki basin is one of these.

SECTION 2

LOOKING FOR OIL

A paleontologist at work. Dr. R. N. Cope examining washed rock cuttings brought up with the drilling mud at Kapuni 1.

SECTION 2

Question 8 - Can you explore for oil wherever you like?

No. Before starting to look for oil in a particular area, it is necessary to obtain from the Government an exploration licence, covering the area. The licence not only allows the company exploration rights but it also imposes certain obligations on it.

Question 9 - What is the first stage in the search for oil?

The first stage is the geological survey. Geologists who have expert knowledge about the earth and its rock formations range quickly over the whole sedimentary basin and, from their examination of rock out-crops, choose those areas which appear to warrant further investigation, either by more detailed geological survey or, if the area is covered with a top layer of earth or swamp which prevents access to rock out-crops, by geophysical survey.

Question 10 - What is meant by geophysical survey?

A geophysical survey is designed to obtain detailed information about the size and shape of rock structures under the ground. In Taranaki, Shell BP & Todd used three methods of geophysical survey - magnetic, gravity and seismic.

Question 11 - What is meant by magnetic survey?

A magnetic survey depends on measuring the intensity and direction of the earth's magnetic field and inferring the distribution of rocks possessing different magnetic properties from the local variations in this field.

Question 12 - What is meant by gravity survey?

When a gravity survey is made, very delicate instruments known as gravimeters are used to measure variations in the earth's gravitational fields. From the information obtained, a rough picture can be drawn of the likely rock structures that exist underground.

Question 13 - What is meant by seismic survey?

Seismic survey provides the most direct evidence of geological subsurface structure at present obtainable. In this method a charge or a series of charges of explosive detonated at or near the earth's surface generates artificial earthquake waves which are relayed to recording devices by a number of sensitive instruments known as seismometers or geophones placed at varying distances from the explosion. By measuring the time it takes for the shock waves to travel downwards and back again, it is possible to deter-

mine the depth of certain rock layers and their shape and contour in relation to other sedimentary rock formations.

Question 14 - Why do you want to know the contours of the rock underground?

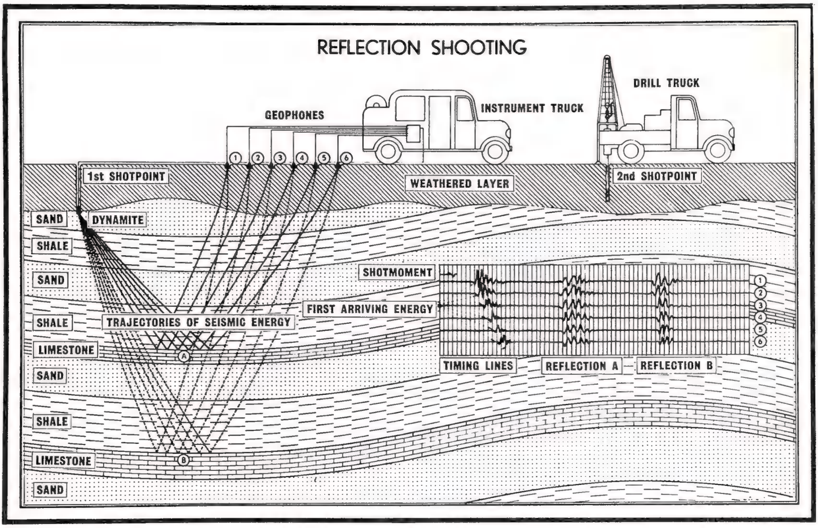
If the contours of the rock underground are known, it is possible to establish the existence of structures and traps which might contain recoverable quantities of oil or gas. The geophysical survey of Taranaki, for example, showed the existence of possible oil-bearing structures in several places in the basin, notably those centred at Kapuni, Mangahewa and Inglewood.

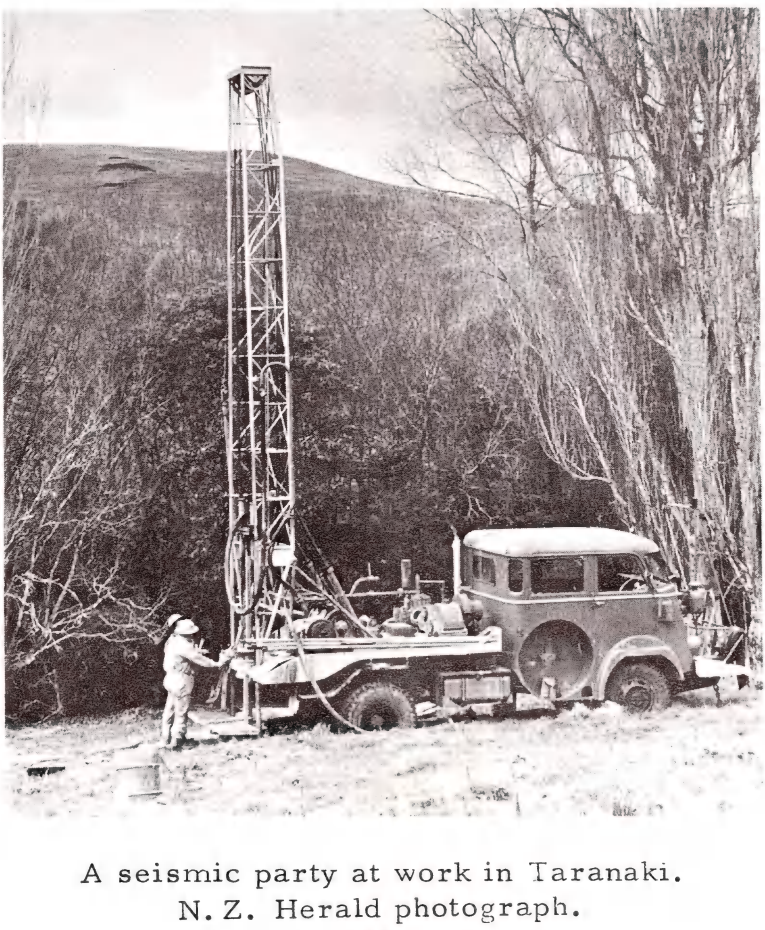
Question 15 - Is Paleontology used in the oil search?

Yes. Paleontology is the study of the fossilised remains of plant and animal life. By examining such fossils in rock sediments, paleontologists can determine the relative ages of the rock formations from which they have been obtained. This information is useful in locating potential oil-bearing areas.

Question 16 - Do you know you will find oil in a structure, or do you merely expect to find it?

We neither know nor expect; we can only hope. It cannot be said too strongly that when an exploration well is drilled into a structure, it is impossible to





A seismic party at work in Taranaki.
N.Z. Herald photograph.

One of the company's seismologists - Mr. J. P. de Loriol-examining some of the seismic information obtained during the early stages of the search.

know for certain beforehand whether there is oil in that structure. The well is drilled in order to find out whether oil or gas is in fact present. The geological and geophysical surveys establish the presence of those structures which stand the best chance of containing oil, but the only way of finding out if they do contain it is to drill an exploration well. Even then only about one exploration well in ten is, as a rule, successful.

<u>Question 17 - When you have established the existence of a possible oil-bearing trap or structure, how do you tell whether it does in fact contain oil or gas?</u>

This can only be done by drilling a well on the structure. When all geological and geophysical data obtained in a certain area have been assembled on a compilation map and a prognosis has been made of the section of layers to be inspected at depth, a location can be selected for an exploration well and deep drilling can start.

<u>Question 18 - Why are you looking for more oil when there is already a world-wide surplus of it?</u>

It is true that the supply of oil today exceeds the demand for it, but it must not be forgotten that the demand for oil is expected to double during the next 15 years

and it is to meet this increase in demand that we must look for oil now. A growth of 100% over such a period may not seem particularly impressive, but when the quantities involved are considered, the magnitude of the task becomes apparent. The demand will be for an additional 20 million barrels daily - 1000 million tons of oil per annum - not just of crude oil but 20 million barrels of finished products delivered every day to markets and consumers all over the world. It is estimated that the oil companies between them will have to find and provide more than £80,000 million to meet this increase in demand.

SECTION 3

EXPLORATION WELLS

SECTION 3

Question 19 - What is an exploration well? Is it the same as a "wildcat" well?

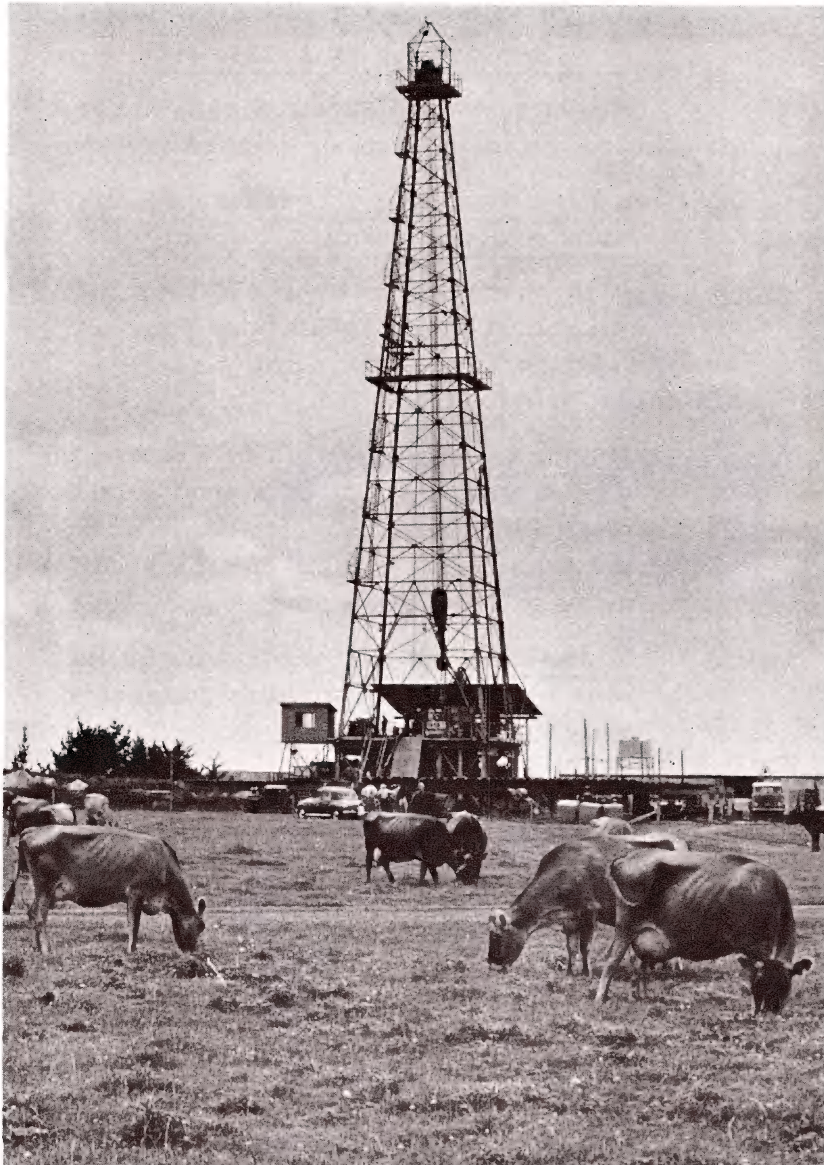
All wells drilled with the object of discovering petroleum accumulations are exploration wells, but are more commonly known - particularly by the men who drill them - as "wildcats", a designation at least half a century old, which emphasises the hazards and the speculative nature of drilling in a new area. A successful "wildcat" is known as a 'discovery well' - Kapuni 1 is one of these, so also is Mangahewa 1 - while unsuccessful "wildcats" are known as 'dry holes'.

Question 20 - How long does it take to drill an exploration well?

It depends on the characteristics of the area in which the well is drilled, the hardness of the rock and the depth of the well. Kapuni 1, which was drilled to 13,040 ft. took nearly $5\frac{1}{2}$ months, while Mangahewa 1, which was about 1,000 ft. deeper than Kapuni 1, took a little less.

Question 21 - What does it cost to drill an exploration well?

This depends very largely on the time taken, the depth reached and the difficulties encountered. Kapuni 1 cost nearly £500,000, and the cost of Mangahewa 1 was not much less.



Kapuni 1 was drilled in the rich dairying area of South Taranaki.

Question 22 - How many exploration wells have you drilled in Taranaki?

To date, two - Kapuni 1 and Mangahewa 1. A third is to be drilled at Inglewood.

Question 23 - What type of drilling equipment are you using at Kapuni?

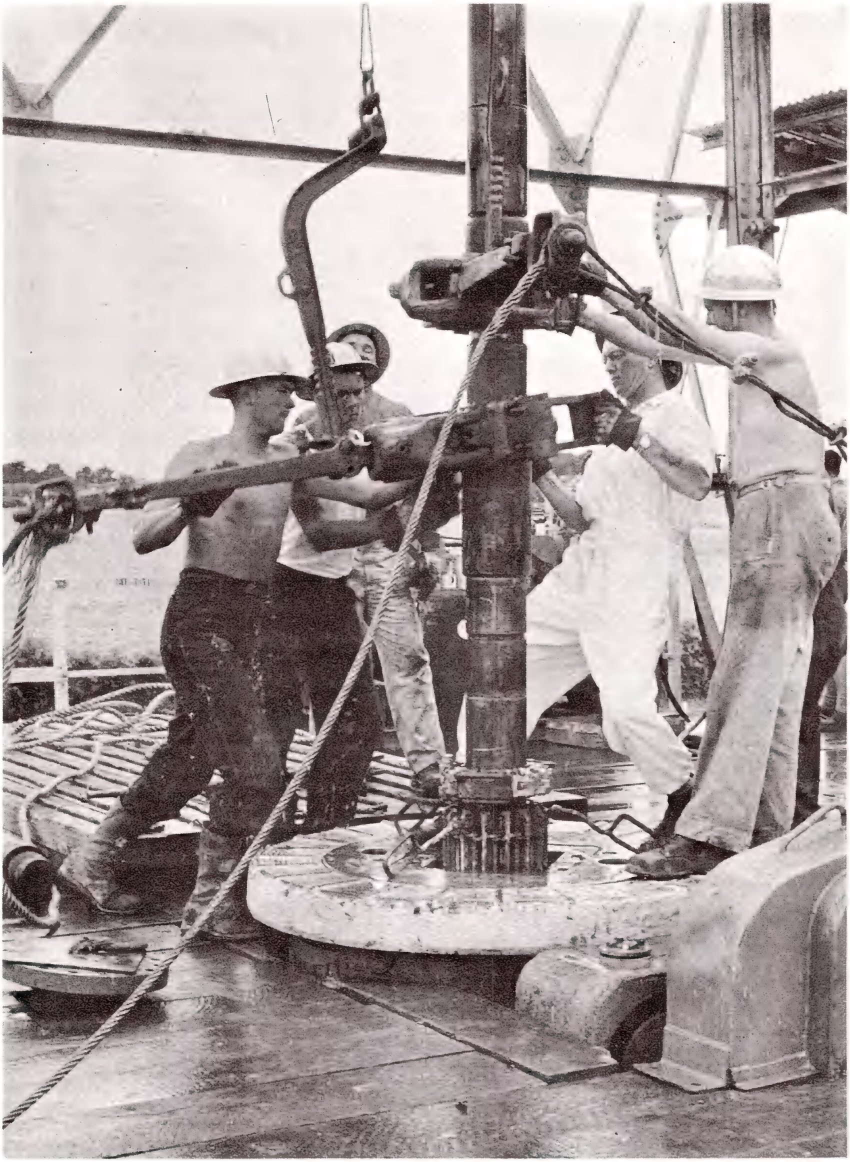
It is known as an Ideal 130 type rig. It weighs in total about 1,000 tons and was imported from Venezuela. Some of the main components are:-

(i) Derrick: The derrick is erected on a platform 16'0" high standing on a base 30'0" square. It is 172 ft. in height and has a load-carrying capacity of 1,300,000 pounds (580 tons).

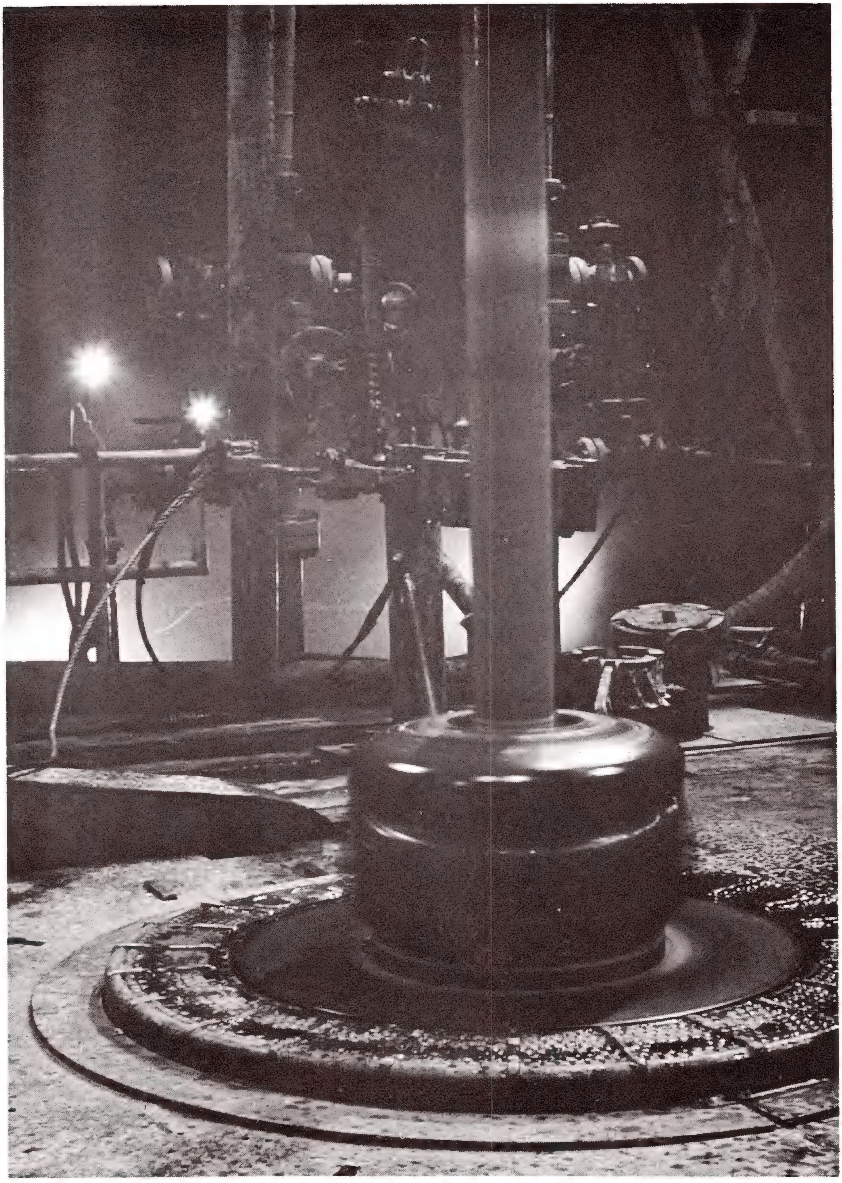
(ii) Travelling Block: This weighs $11\frac{1}{2}$ tons and can comfortably support a weight of 500 tons.

(iii) Draw Works: These are capable of hoisting 400 tons at the rate of 30 ft. per minute. Lighter weights of course can be hoisted in quicker time. A weight of 30 tons, for example, can be lifted at the rate of 3,000 ft. per minute.

(iv) Engines: The rig is powered by four 500 h.p. Paxman 12 RPXH supercharged engines connected through fluid couplings to a compound drive, so that any or all can be used for winching or pumping.



A drilling crew at work at Mangahewa 1.



Drilling goes on 24 hours a day, 7 days a week.

(v) Main Pumps: These are capable of delivering at rates varying from 900 gallons per minute at 1200 p.s.i., to 400 gallons per minute at 3,000 p.s.i.

(vi) Drill Pipe and Drill Collars: The principal drilling "string" has an outside diameter of 5" and an inside diameter of $4\frac{1}{4}$". It weighs 20 pounds per foot and has a tensile strength of 80,000 p.s.i. At the bottom end of the drilling "string" are the drill collars consisting of heavy thick-walled pipe. These drill collars vary in size and length according to the diameter of the well, but can have an outside diameter as great as 10". A drill collar of this diameter weighs 213 pounds per foot.

The weight of the drilling "string" in drilling mud at 13,000 ft. is about 260,000 pounds.

(vii) Bits: Rock bits with ball and roller bearings are used exclusively. They have teeth of various sizes and shapes for use in the different types of formation likely to be met.

The weight exerted during drilling on a bit of $8\frac{1}{2}$" diameter is about 40,000 pounds and the speed of rotation is 100 r.p.m.

The operation of the rig is described in Section 6.

Question 24 - What is the purpose of drilling mud and why is it so essential?

While drilling is going on, powerful pumps circulate mud down the drill-pipe around the bit, up between the drill-pipe and the walls of the hole and finally to a mud pit on the surface.

The circulating mud reduces friction, cools and lubricates the bit, stops wear and speeds the job. The mud flow also brings to the surface cuttings which are representative of the type and nature of the formations being penetrated. It may also contain traces of oil, gas or salt water present at the underground levels.

By plastering up the sides of the hole, the mud also prevents the walls from caving in before the steel casing is run and allows the drilling "string" to pass smoothly in and out of the hole.

On its journey downwards, the bit may penetrate formations holding gas, oil or water under pressure. In such cases the mud provides a counter-pressure which restrains the gas or liquid from surfacing until it can be brought up under control.

Question 25 - How do you stop oil or gas blowing out the top of the well?

Below the derrick floor and mounted

An important aspect of the drilling operation. Mr. P. W. Stainton in the Shell BP and Todd laboratory identifying rock types from cuttings brought up from far below the earth's surface at Kapuni.

directly on the well casing are four blow-out preventers. These valves are used when the weight of the mud column is not great enough to prevent underground pressures from forcing the mud out of the hole. The valves are hydraulically operated and are tested to operate against pressures up to 5,000 p.s.i.

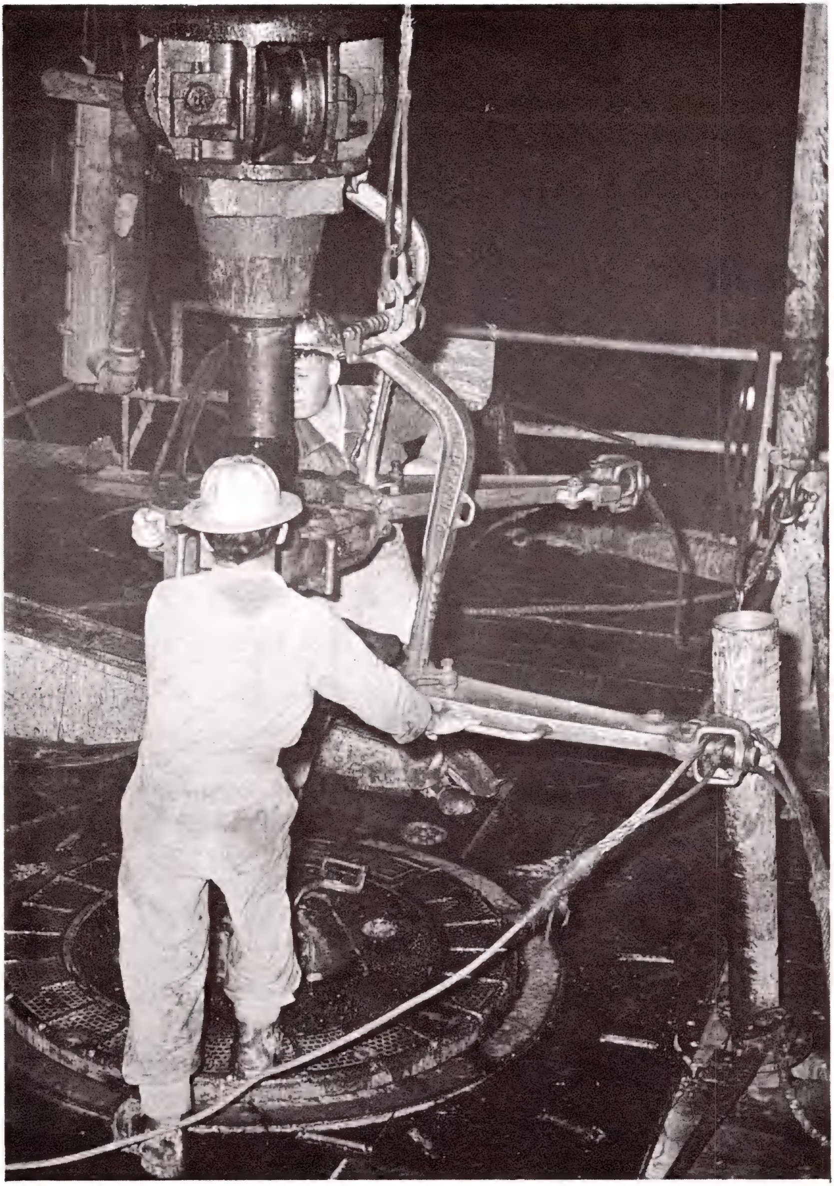
Question 26 - How many men do you employ on an exploration well?

Four drilling crews operate the rig for 24 hours a day, 7 days a week. They work in three shifts and each man works six days on and two days off. A crew consists of a driller and six other men.

In addition to the drilling crews, 19 other men are employed on the rig site as drivers, welders, mechanics, laboratory assistants, production gaugers, riggers and general labourers.

Question 27 - Can you tell whether the rock you are drilling through does in fact contain oil?

No, but examination of the rock cuttings brought up with the drilling fluid can often give helpful information. In addition, by the use of an electrical logging device which is lowered into the well before it has been lined with steel casing, the presence of oil or gas can often be inferred and the porosity and percentage of oil saturation can be estimated.



A shot taken at Mangahewa in the early hours of the morning.

The various intervals which show signs of being oil-bearing can be noted so that tests can be made on them after the casing has been cemented into position.

Question 28 - When the well has been cased, how do you test these promising intervals?

Holes are shot through the casing opposite the apparently productive layer, by means of a "gun perforator" which is lowered into the hole on conductor cables and carries explosive charges which are detonated electrically. Steel bullets are fired through the casing and cement, and if oil or gas is present in the formation which has been penetrated, it will of course flow through the casing and up the well to the surface.

Question 29 - What percentage of success do you have in drilling "wildcat" wells?

Considered on a world-wide basis, only about one in 10 produces anything, and the proportion of those leading to commercial production is very much less than that.

Question 30 - If exploration wells are so speculative in character, surely a good deal of money must often be spent without result?

Indeed it is. In Canada for instance, one company drilled 137 dry holes over 28

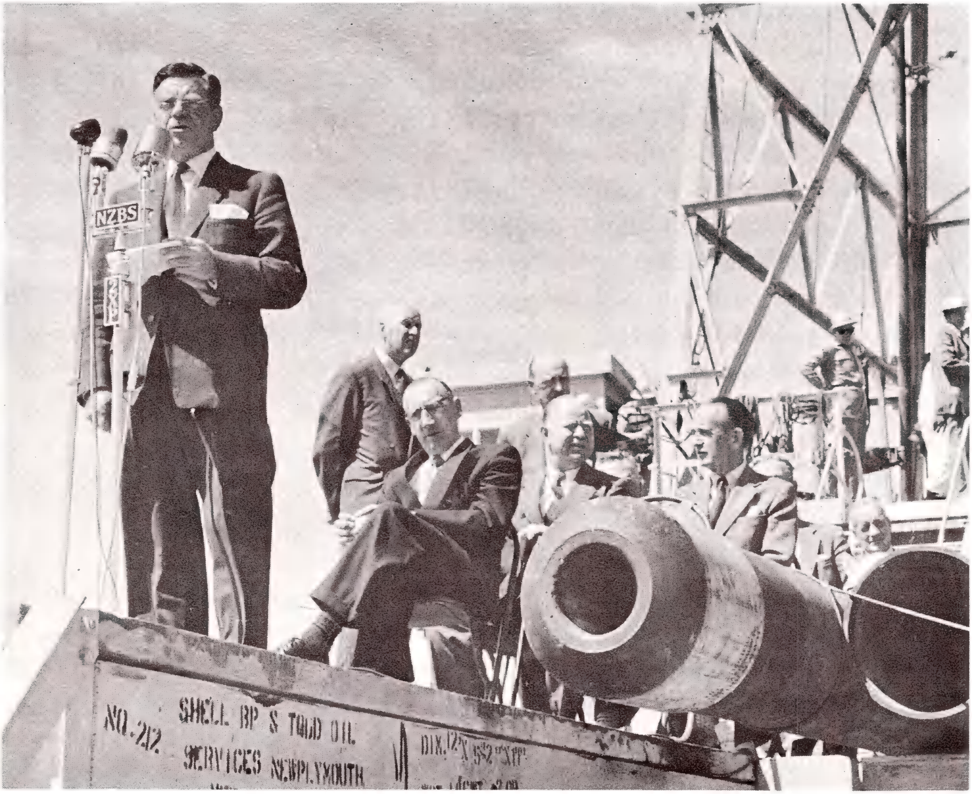
years, before striking oil in 1947. In the Zubair fields in Iraq, £18 million was spent over six years before production began in 1951. In Equador, the Shell Group spent £9 million over six years and had to abandon the search in 1950 without result. Just recently BP Shell & Todd Petroleum Development Ltd. drilled two exploration wells in the area south of Gisborne, at a cost of about £1½ million, with no result.

Question 31 - Is the record of Shell BP & Todd Oil Services Ltd. in Taranaki unusual in that their first two exploration wells have both been successful?

It is almost unique.

SECTION 4

EARLY "WILDCAT" SUCCESSES IN TARANAKI



The Chairman of Directors of Shell BP and Todd Oil Services Limited, Mr. J. B. Price, speaking during the ceremony preceding the spudding in of Kapuni 1 on 27th January 1959. The spudding in was performed by the Minister of Mines, the Honourable F. Hackett (third from right). Seated on the extreme right is Mr. B. J. Todd, and next to him Mr. L. G. Hucks, both of whom are Directors of the company.

SECTION 4

Question 32 - What were the characteristics of Kapuni 1?

This well was the first to be drilled on the Kapuni structure. It was spudded-in on the 27th January, 1959, and was drilled to a depth of 13,040 ft. It produced a strong flow of wet natural gas from which a quantity of light waxy oil was separated by condensation. Approximately 40% of the gas was CO_2. The gas existed in the producing interval at very high temperature and pressure, and when surface conditions were met, the expansion of the gas caused a drop in temperature sufficient to solidify the condensate. Production tests were therefore hampered and representative production rates could not be obtained. For a time, however, gas was flowing at between one and two million cubic ft. per day, and condensate was produced at the rate of about 125 barrels with every million cubic ft. of gas.

Question 33 - What were the characteristics of Mangahewa 1?

This well was started on the 1st November 1960, on a structure some 30 miles away from Kapuni and by the 18th April had reached its final depth of 14,049 ft. Tests made on a number of intervals revealed the presence of natural gas together with smaller quantities of condensate than at Kapuni 1, and large quantities of water. The gas contained less CO_2 than that produced at Kapuni 1.

Question 34 - Were you satisfied with the results of these two exploration wells?

Indeed we were. While we were primarily looking for accumulations of liquid oil, we were very pleased to have located two sources of natural gas which is an extremely valuable fuel for domestic and industrial purposes. In addition, the condensate is entirely suitable for processing at the Whangarei refinery.

Question 35 - Why did you not drill a second well at Mangahewa?

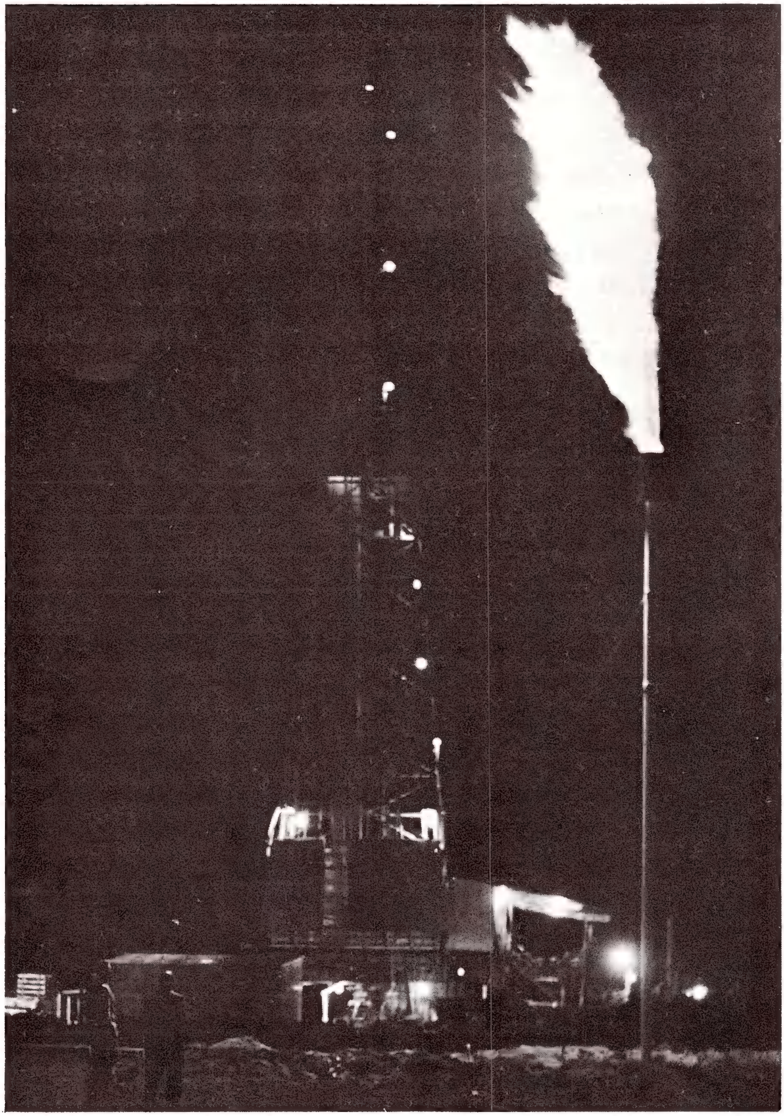
The Kapuni structure appeared on balance to hold out greater promise than Mangahewa and we therefore decided to drill a number of appraisal wells on it. We can always turn to Mangahewa later.

Question 36 - What have you discovered at Kapuni?

We have discovered the existence of a large structural feature which contains an important gas/condensate reservoir at a depth of about 12,000 ft.

Question 37 - What is condensate? Is it in fact, oil?

The hydrocarbons trapped in the Kapuni reservoir exist underground in the form of a gas under very high pressure. When this gas reaches the lower pressure conditions on the surface a percentage of light oil separates out from it. This is



The flare burning at Kapuni 1 immediately after the initial discovery of the natural gas reservoir.

Taranaki Daily News photograph.

what is known as condensate. It is in fact a light crude oil.

<u>Question 38 - Has the condensate any practical use?</u>

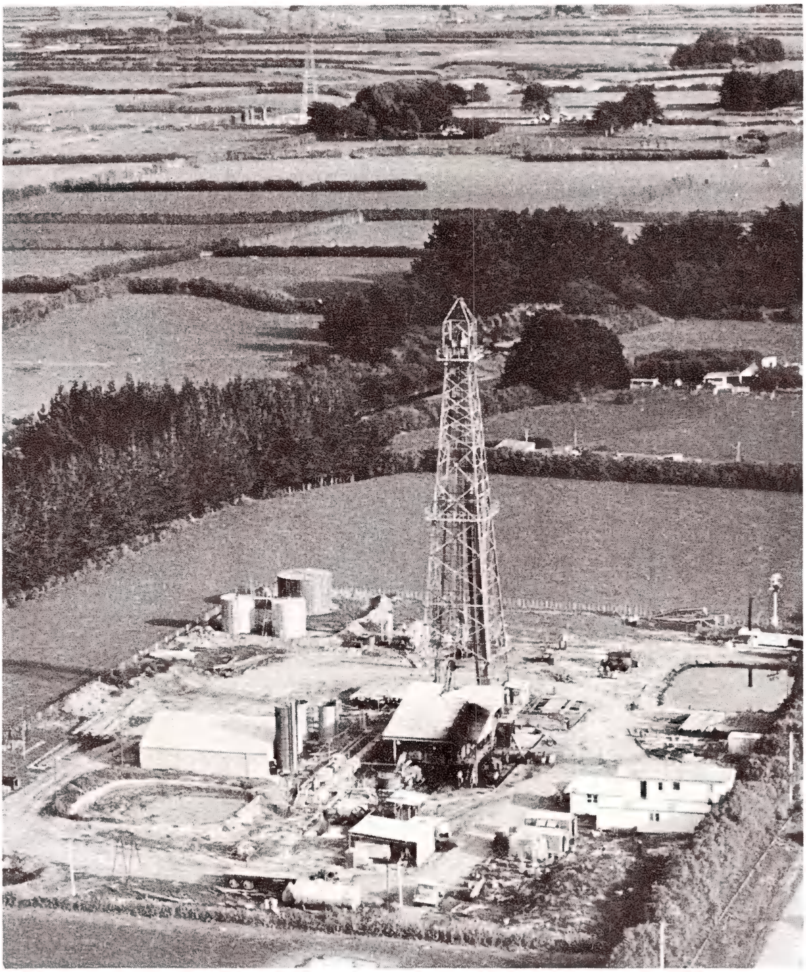
It certainly has. It contains about 50% motor spirit and is a very suitable feedstock for the New Zealand Refinery at Whangarei.

<u>Question 39 - What sort of gas is produced at Kapuni?</u>

Kapuni gas is a petroleum gas mixed with about 40% of carbon-dioxide. Once the latter has been removed the gas can be used as a very efficient fuel for both domestic and industrial purposes.

SECTION 5

APPRAISING A STRUCTURE



Taranaki Daily News photograph.

The Minister of Mines, the Honourable T. P. Shand, examining samples of condensate produced along with natural gas during the testing of Kapuni 2.

SECTION 5

Question 40 - What is an appraisal well?

After oil or gas has been discovered, the first wells to be drilled with the object of establishing the extent of the accumulation are known as appraisal wells. The object of appraisal wells is to determine whether sufficient oil or gas is available for commercial production - that is, whether an oilfield exists or not.

Question 41 - When appraising the potential of a structure, how much information can you get from one well?

The drilling of each appraisal well marks a further step in the gradual definition of the limits of the accumulation. It may take four or more appraisal wells to determine whether petroleum is present in commercial quantities or not. This may take two years or more and it is quite possible that oil in commercial quantities may then not be found. At Kapuni we are fortunate in that we are able to make a preliminary appraisal of the structure after drilling only four wells, but they are deep wells and therefore expensive ones.

Question 42 - What sort of information do you get from an appraisal well?

If the well produces gas or oil, it is allowed to flow for a day or two or even longer, in order to determine the initial

Preparing the site for a new Taranaki "wildcat" - Inglewood A (right foreground).

rate of flow. A certain amount of useful information can be obtained from such a test - particularly pressure data - but usually not enough to determine the rate at which the flow will decline during actual production and, therefore, not enough to say how much the well will actually produce.

Question 43 - Other than pressure measurements and rates of flow, what information do you need in order to estimate the minimum potential of a structure?

Samples of the hydrocarbons and of the oil bearing sands from the reservoir are necessary, so that the conditions underground can be artificially recreated in the laboratory. Tests can then be made which will show how the reservoir is likely to behave when in production and appropriate calculations can also be made to arrive at an estimate of the production potential.

Question 44 - How many appraisal wells must you drill before you know with certainty how much oil or gas is present in a structure?

There is no single answer to this question but our experience at Kapuni provides an illustration of the sort of thing that can happen.

The results of the tests made at Kapuni 1, supplemented by the information gained at Mangahewa which is a structure

similar in type to Kapuni, enabled us to make tentative estimates of the potential production of the structure. Before we could make a reliable calculation, however, we found it necessary to drill at least three more wells. Kapuni 2 and Kapuni 3 gave us information about the southern part of the structure and Kapuni 4, if successful, should give us enough information about the northern part to enable us to establish a minimum reserve to give commercial production. Not until then will it be possible to say whether we have a gas/condensate field.

<u>Question 45 - What do you mean by "commercial production"?</u>

The phrase "commercial production" simply means "profitable production". It is necessary to weigh up on the one hand the estimated production of the field and the financial return this is likely to bring and, on the other hand, the costs of drilling the wells, getting the products to the market and operating the field through its estimated life-time. If the whole operation looks as if it may be profitable, then commercial production may be in sight.

<u>Question 46 - What did you find in Kapuni 2?</u>

We drilled Kapuni 2 to a depth of 13,672 ft. Gas was produced at varying rates up to 6.74 million cubic ft. a day, together with some 500 barrels per day

of condensate. The well thus confirmed the presence of an important gas/condensate reservoir at about 12,000 ft.

Question 47 - What did you find in Kapuni 3?

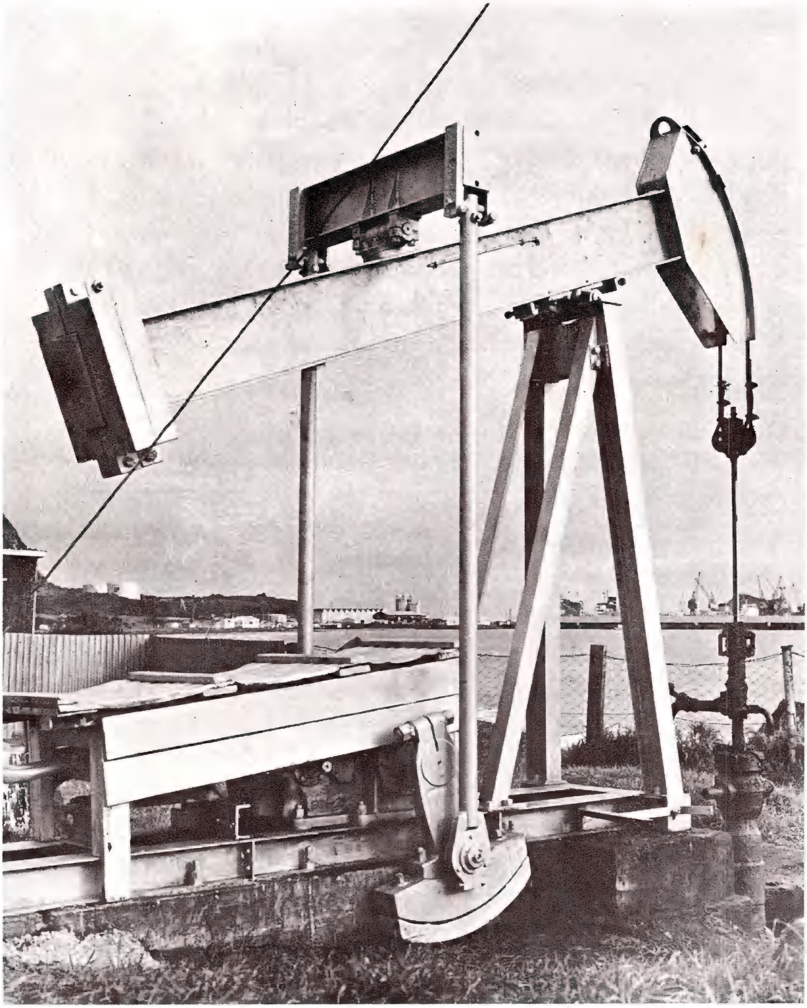
Kapuni 3 was drilled to a depth of about 12,500 ft. and gave results broadly similar to those at Kapuni 2. The well confirmed that the reservoir already discovered in Kapuni 1 and Kapuni 2 extends into the southern end of the Kapuni structure.

Question 48 - What is the purpose of Kapuni 4?

Kapuni 4 is being drilled a little more than a mile to the north of Kapuni 1 and it is hoped that it will confirm that the reservoir extends into the northern end of the structure as well.

SECTION 6

THE NEW PLYMOUTH WELLS



SECTION 6

Question 49 - Is there any connection between the New Plymouth oilfield at Moturoa and the structures which have been investigated at Kapuni and Mangahewa?

None at all. The New Plymouth wells have for many years been producing very small quantities of a waxy crude oil from an entirely separate structure at a depth of about 2,000 ft. Production has been slowly declining for some time, however, and the present rate is in the vicinity of 13,000 gallons per month. Small quantities of gas are also produced and fed into the town coal-gas supply.

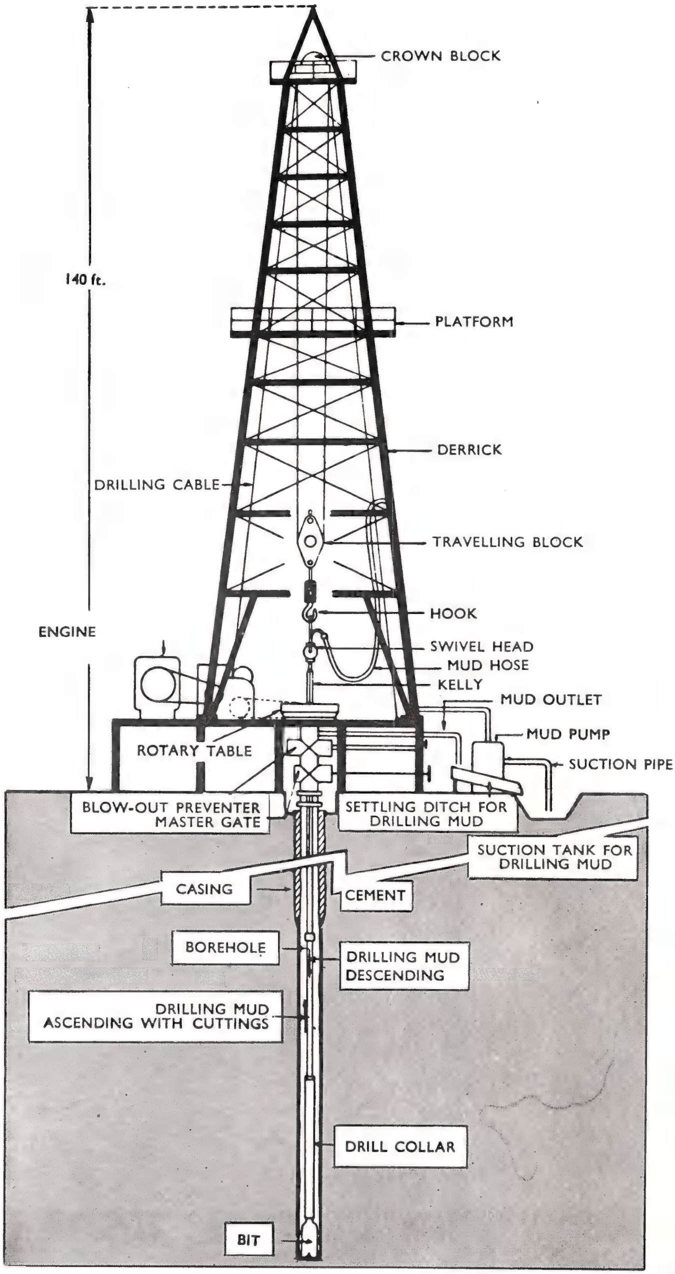
Question 50 - Is it possible to step up production from this field and would you be likely to find more oil by drilling deeper?

It is not possible to answer this question without first making a thorough survey of the whole area. At the time the wells were drilled, no reliable logging was done on them and a great deal of work will have to be done before a proper evaluation of the field can be made. For the present, the work at Kapuni and elsewhere must clearly take pride of place but it may be possible later on to undertake an examination of the Moturoa area.

SECTION 7

DRILLING TECHNIQUES

DIAGRAM OF ROTARY DRILLING RIG



DESCRIPTION

An oil drill comprises steel pipes screwed together, with the bit, or cutting tool, at the lower end and a circulating head or swivel at the upper end.

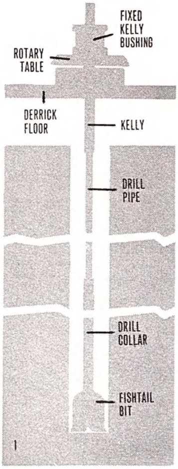
This drilling 'string' is hollow and through it a thick liquid 'mud' is continually circulated by pumps.

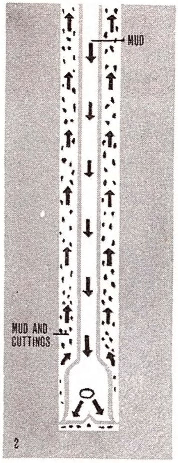
The mud is forced outward through holes in the bit and passes upward outside the string, between it and the walls of the hole.

On the floor of the rig is a rotary table with a square hole in its centre through which the first part of the drill string, which is square and known as a kelly, can pass. When drilling, the table is driven round by an engine, and rotates the kelly and with it the whole of the drill string. As the bit cuts its way downwards the whole string slowly sinks with it.

When the top of the kelly is almost down to the rotary table it is stopped. The 'mud' pumps are shut down and the flow of circulating 'mud' comes to a standstill. The drill string is lifted until the upper end of the first round pipe emerges to the level of the rotary table. The pipe is wedged here by 'slips', which support the whole length of string. The kelly is then unscrewed and put aside. A new 30 ft. length of pipe is hoisted vertically over the

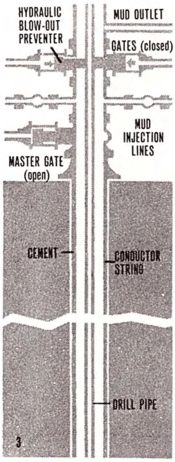
table and screwed on top of the first length of pipe. The whole length of string is lifted by the draw works and the slips are removed. The string is then lowered until the upper end of the round pipe just protrudes above the table, where it is wedged again by the slips. The kelly is hoisted into position and screwed on again. The slips are removed and the string is then lowered until the bit touches the bottom of the hole. The rotary table starts to turn, the 'mud' pumps to work, and drilling recommences. Slowly the kelly sinks through the square hole in the rotary table as the bit cuts through the rock, until its top once more comes down almost to the level of the table. Then drilling again ceases and another length of drill pipe is added. And so on until the well is completed at a depth of, perhaps, 18,000 feet.

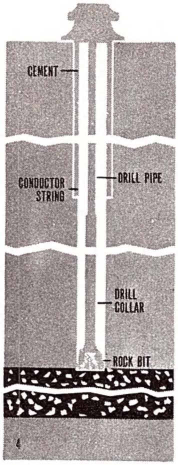




1. A well is started when the engine turns the rotary table, which spins the square kelly running through its centre. At the end of the kelly is a bit which bites into the earth. When the kelly top comes down to the rotary table the engine is stopped, the kelly is hoisted up and a special length of heavy drill pipe, called a drill collar, is added. The order of the drill string soon becomes: kelly, many lengths of drill pipe, two or three drill collars and a bit.

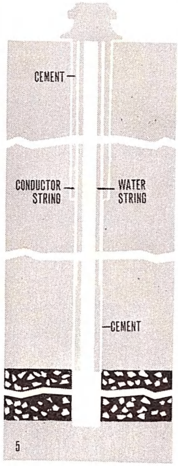
2. Powerful pumps force drilling mud through the kelly, down the drill pipe and drill collar, through holes in the bit and back up to the surface around the outside of the drill string. The function of the mud is to bring up rock fragments from the drilling (from an examination of which the nature and age of the rocks are known), to support the walls of the well, to prevent oil, gas or water under pressure from blowing out, and to keep the bit cool.



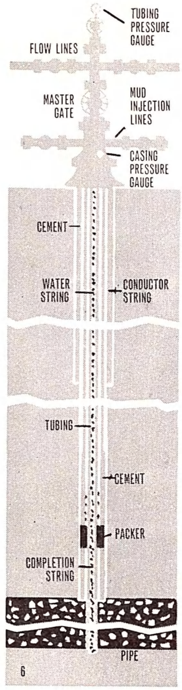


3. After drilling a short distance a steel lining, called a conductor pipe, perhaps of 16" diameter, is lowered and set firmly in position by cement between it and the walls of the well. When the cement has set, a master gate and hydraulic blow-out preventer are fixed to the conductor pipe. By a special arrangement of valves which are vital to safety the well can be closed in from a distance if high pressure is met.

4. After this has been done, drilling is continued with a reduced diameter hole. With a deep well, more steel lining or casing will have to be set to support the walls as the bit works deeper.

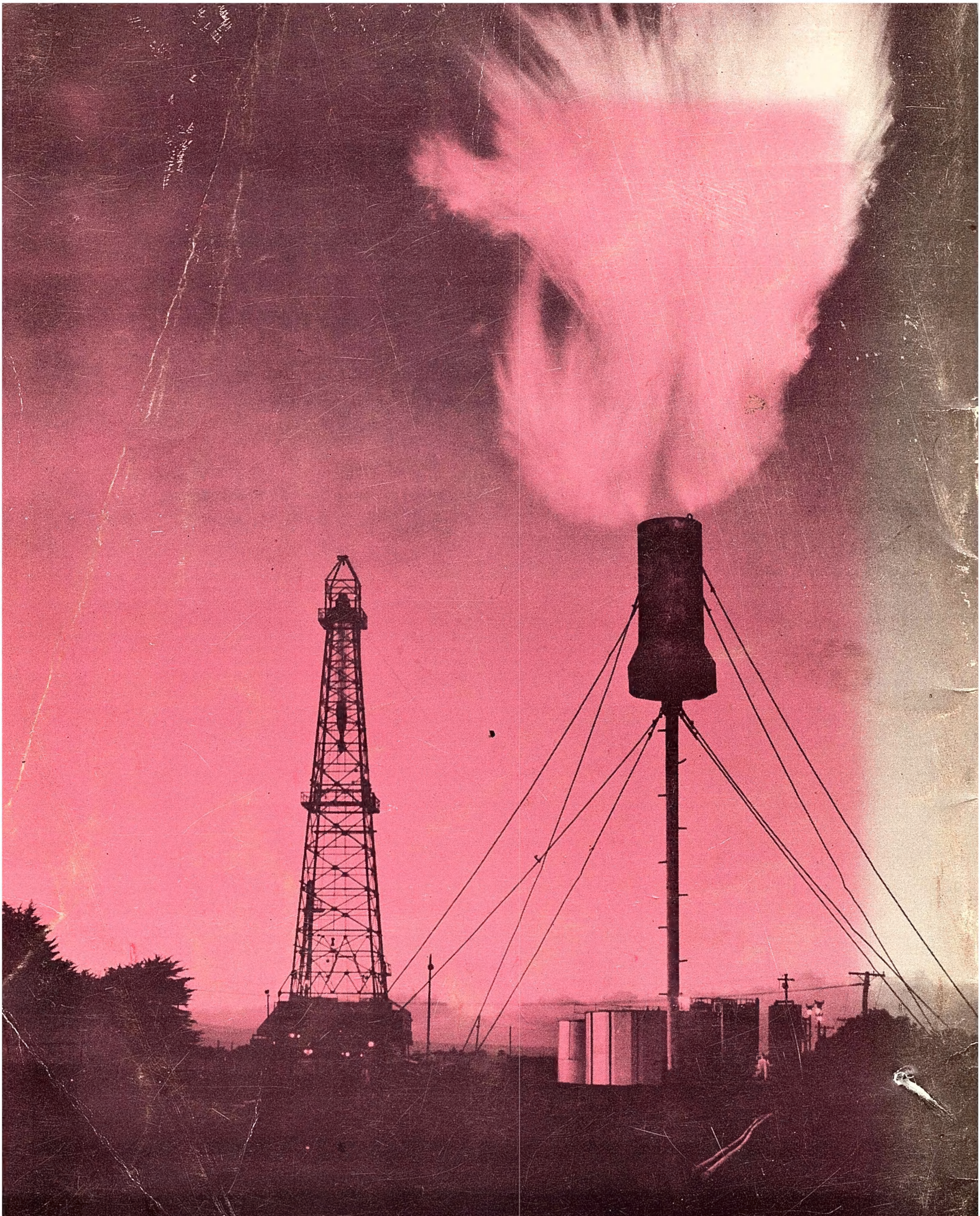


5. When the mud coming up from the depths of the well shows that the bit has struck an oil-bearing layer, or oil sand, drilling is continued until its exact thickness is known. The whole string is then pulled out and the oil kept down by the weight of mud above it. Smaller diameter casing is lowered to just above the oil sand and anchored with cement. Its purpose is to keep out water.



6. Next a screen pipe is lowered through the layer of oil sand and, acting as a filter, prevents sand from entering with the oil and gas. Narrow tubing is then run down to the screen pipe to conduct the oil and gas to the surface.

The last stage before the well begins to produce is to get rid of the heavy mud by displacing it with water.



The gas flare at Kapuni 3. At the time the photograph was taken, the gas was flowing at a rate of about 6,750,000 cubic feet per day - approximately the amount of gas used each day by the cities of Auckland and Wellington combined.